Steering device for vehicles having a pair of wheels which can be steered freely by means of lateral forces

Description

The present invention relates to a steering device for a vehicle according to the preamble of patent claim 1.

Such a steering device is known from DE 198 03 745 A1. The vehicle described there has a freely steerable axle which is also referred to as a self steering axle and whose steering can be locked as a function of predefined operating states of the vehicle. In particular, the intention is that this steering system will be locked when a minimum velocity of the vehicle is exceeded. Furthermore, sensors for sensing the velocity of the vehicle, the steering angle of the steerable axle and brake pressure are provided and are connected to an electronic control device. Depending on predefined measured values of the sensors, the electronic control device releases a locking device for the self steering axle or activates it.

DE 100 65 186 A1 describes a hydraulically activated steering device of a utility vehicle with two axles which can be steered actively by means of a hydraulic system. An electronically controllable damping valve is connected into the hydraulic circuit and can be adjusted to a stored characteristic curve as a function of the load state of the vehicle.

DE 198 12 238 A1 describes a method for controlling the yaw behavior of vehicles. Sensors for the vehicle velocity and the steering angles are connected to a control unit which determines the yaw rate of the vehicle. Two independent control circuits for a steering intervention and a braking

intervention control the yaw rate in accordance with a predefined setpoint value.

Heavy trucks and many buses have a third axle in addition to a front axle which can be steered by the driver and a driven, nonsteerable rear axle. If the third axle is arranged behind the driven axle, it is referred to as a "trailing axle".

A distinction is made between vehicles in which the third axle is rigid, i.e. cannot be steered, and the vehicles in which it is steerable. In the case of steerable third axles, a distinction is further made between axles which are coupled kinematically to the front axle steering system, i.e. which are also steered automatically by the driver together with the front axle and what are referred to as "lateral force steered axles". Lateral force steered axles are not coupled to the steering system of the vehicle and are therefore also referred to as "freely steerable axles". If the vehicle travels round a bend, laterally directed positive forces arise between the underlying surface and the wheels of the lateral force steered axle and lead to an "automatic" steering lock.

In comparison to other multiaxle vehicles in which a plurality of axles are arranged rigidly, i.e. one behind the other in a nonsteerable fashion, the wear on the tires in vehicles with steerable "additional axles" is less, in particular when cornering at low velocities, and the vehicle has a better turning circle. However it is considered to be disadvantageous that vehicles with one or more freely steerable axles have a smaller degree of "lateral rigidity" and thus worse stability on bends compared to vehicles with nonsteerable axles.

In particular in the case of low coefficients of friction and on a smooth underlying surface, vehicles with freely steerable axles tend to oversteer more readily than vehicles with rigid axles. The tendency to oversteer is increased further if the nonsteered axle is driven and also has to transmit drive forces in addition to the lateral guiding forces.

From the applicant-internal prior art, vehicles with a second rear axle are known which are steered by lateral force and in which the lateral force steered axle can be locked "where necessary", i.e. in which the degree of freedom of the steering can be locked. The locking or blocking is carried out here exclusively as a function of the velocity of the vehicle, with the axle being locked above a specific minimum velocity. Such vehicles have significantly improved lateral rigidity at relatively high velocities compared to vehicles with a lateral force steered axle which cannot be locked. At the same time, the free steerablility at low velocities allows the wear on tires to be reduced.

The object of the invention is to provide a steering device for further improving the driving stability of vehicles with a lateral force steered axle, in particular in order to reduce the risk of oversteering.

This object is achieved by means of the features of patent claim 1. Advantageous refinements and developments of the invention can be found in the subclaims.

The basic principle of the invention is to control the locking or blocking of a lateral force steered axle on the basis of a plurality of criteria, specifically as a function of the velocity of the vehicle, and additionally as a

function of variables which characterize the instantaneous driving stability or lane holding of the vehicle.

The driving state of a vehicle can be described approximately by means of a complicated vector variable which is composed, for example, of the components of wheel speeds, wheel acceleration values, slip values at individual wheels, translatory and rotational vehicle acceleration or yaw rate, mass of the vehicle, distribution of axle load, steering angle, engine torque, braking torque at individual wheels etc.

By monitoring a plurality of such variables and by means of a comparison with predefined "critical" individual values or critical combinations of individual values it is possible to estimate the instantaneous driving stability of the vehicle more realistically. If a critical driving situation is detected, the driving stability, in particular the lateral stability when cornering, can be improved by locking the lateral force steered axle.

In order to monitor the driving state it is possible to use an electronic stability system which is usually present in any case in modern vehicles. In addition to the locking of the lateral force steer axle, interventions can also be made into the engine torque, and braking interventions can be made at an individual wheel or at a plurality of wheels.

According to one development of the invention, a locking device which is provided for locking the lateral force steered axle is activated by means of a central electronic control device. If the driving state of the vehicle has stabilized again as a result of the control intervention, the lateral force steered axle can be "released" again.

According to one development of the invention, an axle is not released again until predefined values which characterize a critical driving situation are undershot for a specific minimum period of time of, for example, 3-5 sec, i.e. if the vehicle has stabilized for a significantly long time.

The locking device may be capable of being activated hydraulically or pneumatically, for example.

According to one development of the invention, steering levers which are connected to one another in an articulated fashion by means of a track rod are provided on the wheels which are at opposite ends of the lateral force steered axle. One of the two steering levers may have, for example, an "extension" which serves as a locking lever and engages in a locking mechanism.

The invention will be explained in more detail below by means of an exemplary embodiment and in conjunction with the drawing, in which:

fig. 1 is a basic outline of a three-axle vehicle with a lateral force steered axle when cornering, and

fig. 2 is a more detailed illustration of the vehicle according to fig. 1.

Fig. 1 shows a vehicle 1, for example a bus, with a front axle which can be steered by the driver by means of the steering wheel and which is formed by two wheels 2 and 3. The vehicle 1 also has a driven rear axle which is rigid, i.e. cannot be steered, and has rear wheels 4 and 5. "Behind" the rear axle a lateral force steered trailing axle is provided which is formed by the wheels 6 and 7 which are coupled to one another by means of a steering mechanism 8.

When cornering, the driver predefines a steering lock by means of the front wheels 2 and 3. When the vehicle is traveling in a stable way, the wheels 6 and 7 which are coupled by means of the steering mechanism 8 move freely. As a result of the lateral positive forces which occur between the underlying surface and the wheels 6 and 7, a corresponding steering lock is brought about automatically at the lateral force steered axle. In the case of the steering lock of the wheels 2, 3 and 6, 7 shown in fig. 1 all the wheels 2-7 have a common, imaginary instantaneous pole M which permits stable cornering.

Fig. 2 is an enlarged illustration of the vehicle in fig. 1. Each of the wheels 2-7 is assigned a wheel sensor 9-14 for determining the wheel speeds V2-V7 and for determining the steering angles $\alpha 2$, $\alpha 3$, $\alpha 6$, $\alpha 7$ of the wheels 2, 3, 6, 7. The signals which are supplied by the sensors 9-14 are evaluated by an electronic control device 15. Purely by way of example, two further sensors are illustrated, specifically a yaw rate sensor 16 and a coupling force sensor 17 which determines the coupling force on the king pin. Alternatively or in addition it is possible to provide further sensors for monitoring the instantaneous driving stability, for example brake pressure sensors for determining the brake pressures at individual wheels, load sensors for determining the axle load distribution and the mass of the vehicle, longitudinal acceleration sensors and/or lateral acceleration sensors etc.

The two wheels 6 and 7 of the lateral force steered axle each have a steering lever 18 or 19 which is permanently connected to the wheel suspension. The two steering levers 18, 19 are connected to one another in an articulated fashion by means of a track rod 20. The two wheels 6, 7 thus have a common "degree of steering freedom". The steering

lever 19 of the wheel 7 has an "extension" which serves as a locking lever 21. When the wheels 6, 7 make steering movement, the locking lever 21 swivels with them. The locking device 22 which is illustrated only schematically here can lock the locking lever 21. Therefore, both wheels 6 and 7 are "locked" by the locking device 22.

The locking device 22 can be actuated electronically by the control device 15, specifically as a function of the velocity of the vehicle and a plurality of measured variables which characterize the driving stability and are sensed by sensors 9-14, 16, 17 which are illustrated only schematically here.

To summarize, the invention can be characterized as follows:

The basic idea of the invention is that, in a vehicle with one or more lateral force steered rear axles, the rear axle steering systems are locked not only as a function of velocity but also in the case of oversteering or in other critical driving situations. This may be done by "retrofitting" an electronic stability system which is provided in any case in the vehicle and which actuates the locking device for the lateral force steered rear axle, i.e. locks when necessary and registers it again after critical situations.

This steering device is suitable, for example, for a bus with three axles in which the central rear axle is driven and the last axle is steered by lateral force and is locked from approximately 40 km/h by means of pneumatic cylinders or hydraulic cylinders. The bus is equipped, for example, with a conventional electronic stability system which is capable of detecting oversteering. If the oversteering of the bus exceeds a specific threshold value, the locking mechanism is activated by the electronic control device by

means of a digital output using a pneumatic or hydraulic valve, and the lateral force steered rear axle is locked, as a result of which an additional lateral guiding force builds up at the steered rear axle and stabilizes the vehicle. After the vehicle has been traveling straight ahead again in a stable fashion for a certain time, i.e. for a period of time of 3-5 sec, the locking mechanism is released again and the rear axle steering system is released again.

Of course, a plurality of such lockable, lateral force steered axles may also be provided in one vehicle.